



## EPC Tag Performance

Daniel Deavours, Director of Research

RFID Alliance Lab

[deavours@ittc.ku.edu](mailto:deavours@ittc.ku.edu)

<http://www.rfidalliancelab.org>

RFID Alliance Lab

- Provide useful, timely, credible, and unbiased data to end users of RFID products
- Constituents:
  - **University of Kansas / ITTC:** Primary research contributor
  - **RFID Journal:** Initial funding, distributor, advertisement
  - **Rush Tracking Systems:** Initiator, subject expert, industry lesion
- Business model
  - Sell reports (~\$1,000 / report) to finance future reports
  - Advisory Board
    - Site license to reports
    - Use facilities, products
  - Work with consumers directly to solve specific problems

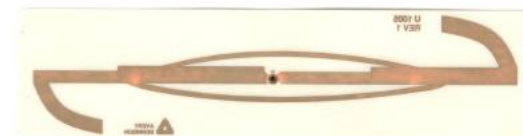
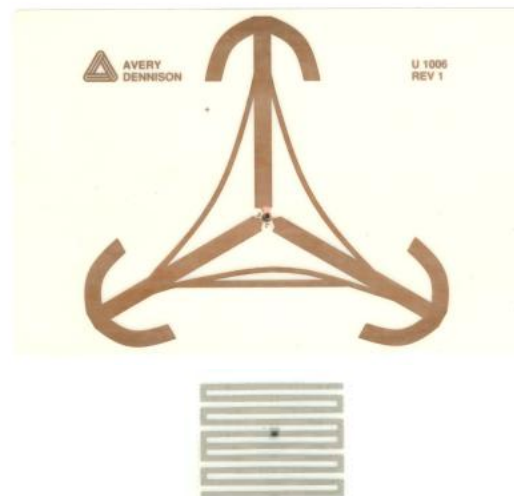
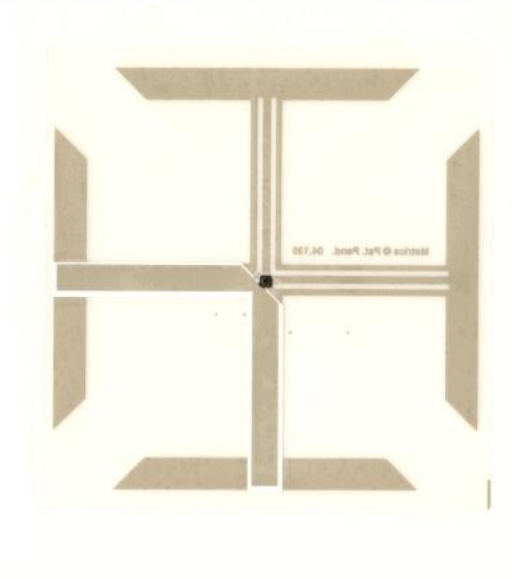
### Studying performance, not conformance

#### Metrics presented here:

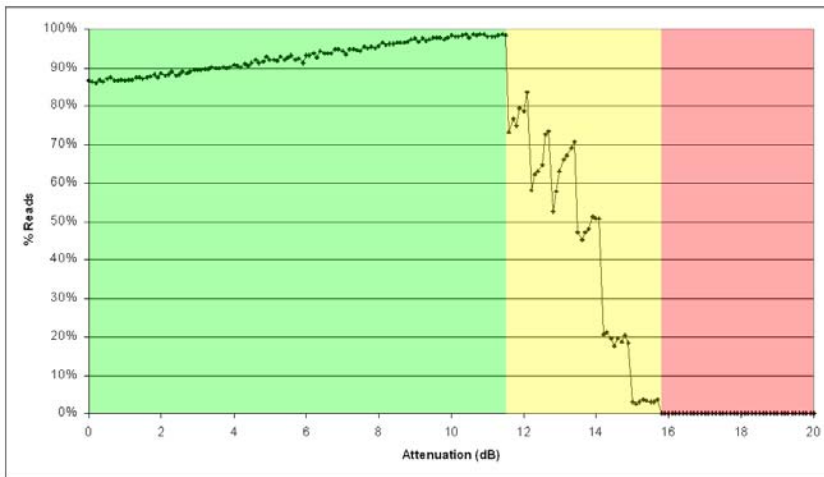
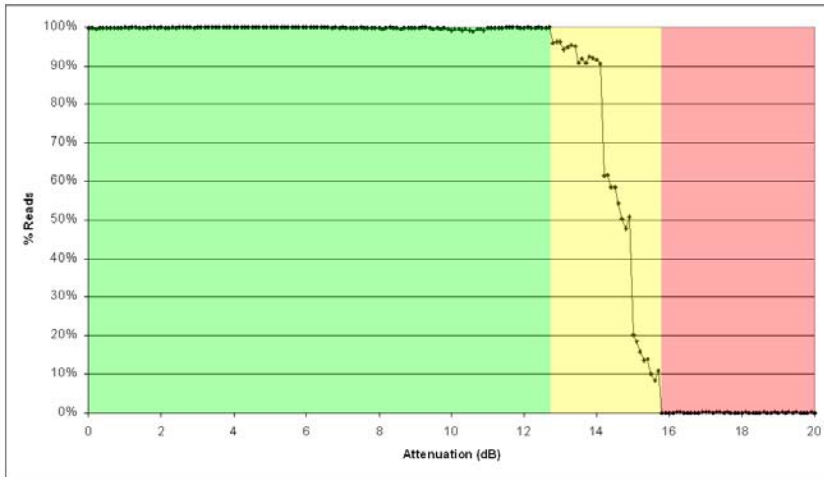
- Tag read distance
- Variance in tag performance
- Orientation sensitivity of tags
- Tags near metal, water
- Tags on cases of products on conveyors
- Tag/reader read rates
  - Individual
  - Population

## Partial list of tags:

- Matrics X2040
- Avery Triflex
- Matrics Pharma
- Rafsec 457
- Rafsec 458 (d)
- Alien 9250
- Alien 9338
- Alien 9254
- Avery U1014 (d)
- Matrics I2010
- Avery DS1

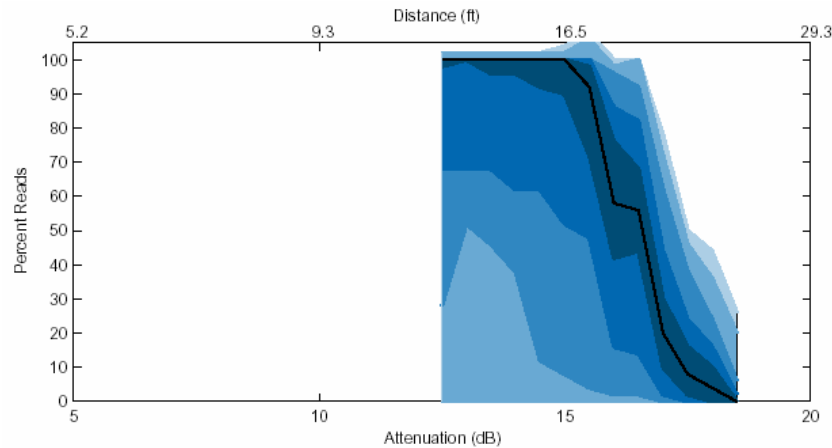


## Tag Performance vs. Distance



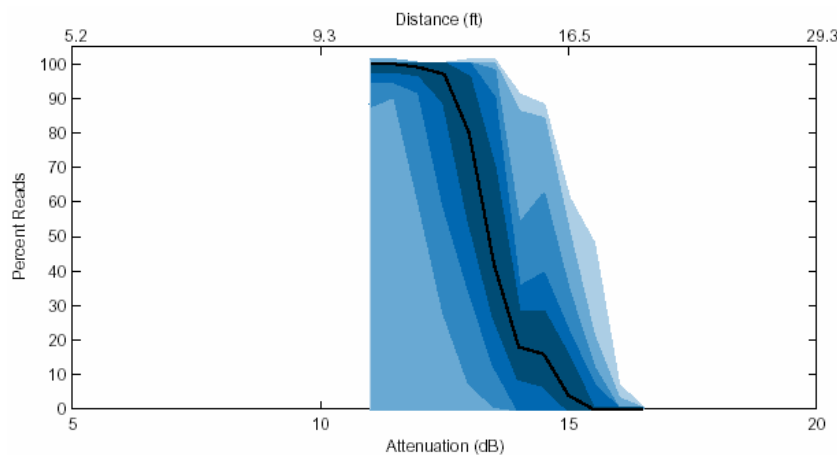
- Typical Class 0, 1 percent reads vs. attenuation (distance)
- Strong in-field
  - 100% vs. 85-99%
- Weak in-field
  - Bumpy/smooth ride down
- Out of field
  - 0 vs. 0.13% “ghost” reads
- *Sometimes further is better*

## Tag Variation — The Bad News

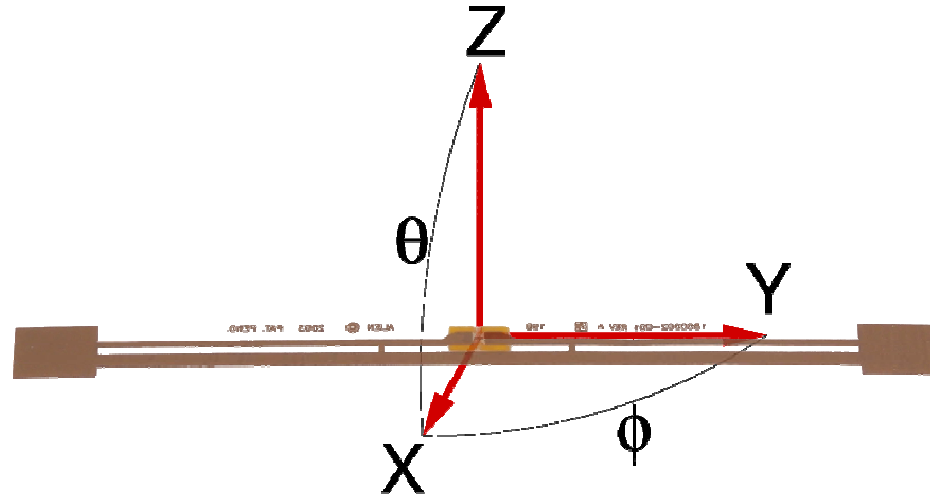


### Tags vary in performance

- Model to model
- Tag to tag
- Narrow bands = high quality
- Far right = high performance



Range	Lower Bound	Upper Bound	% Included
Black	50%	50%	1 tag
Darkest	30%	70%	40%
	15%	85%	70%
	6.5%	93.5%	87%
	1%	99%	98%
Lightest	0%	100%	100%

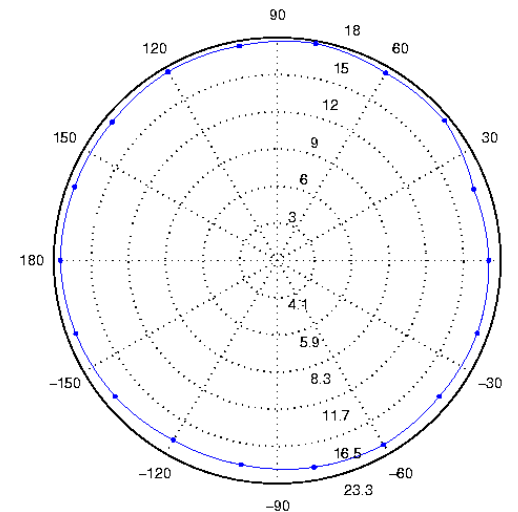
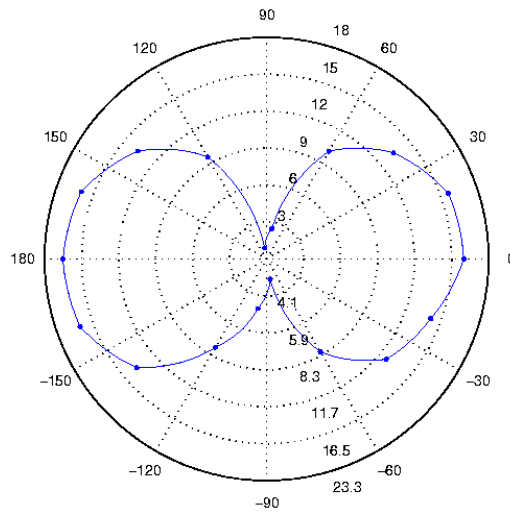


**Rotation along the X-Y axes:**  $\phi$

**Rotation along the X-Z axes:**  $\theta$

**Rotation along the Y-Z axes:** twisting

- Should not matter w/ circularly polarized antennas, but varies with quality of antenna

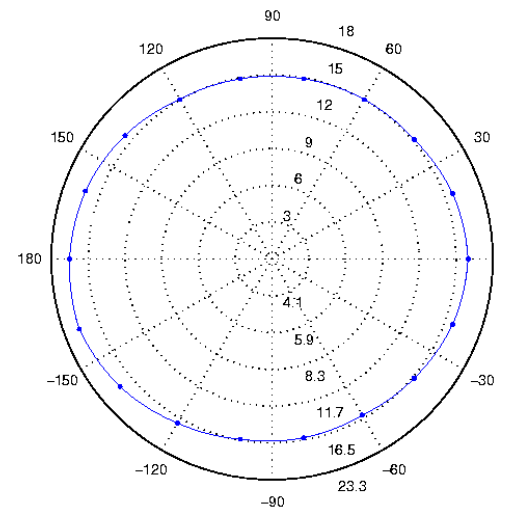
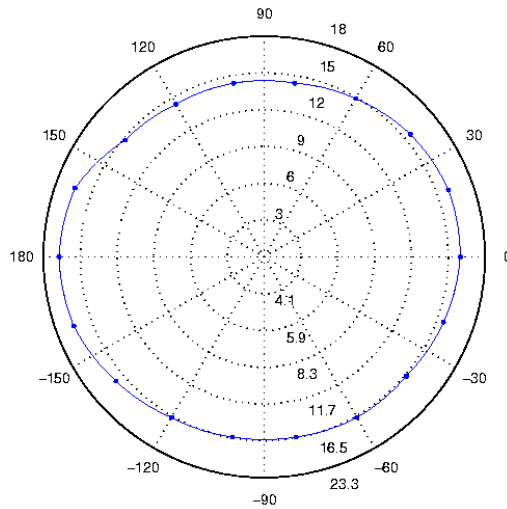


### Characteristic of all long, narrow tags

- Read range nearly zero when looking at ends of dipole
- Read performance nearly uniform along other axis



## A “Dual Dipole” Design



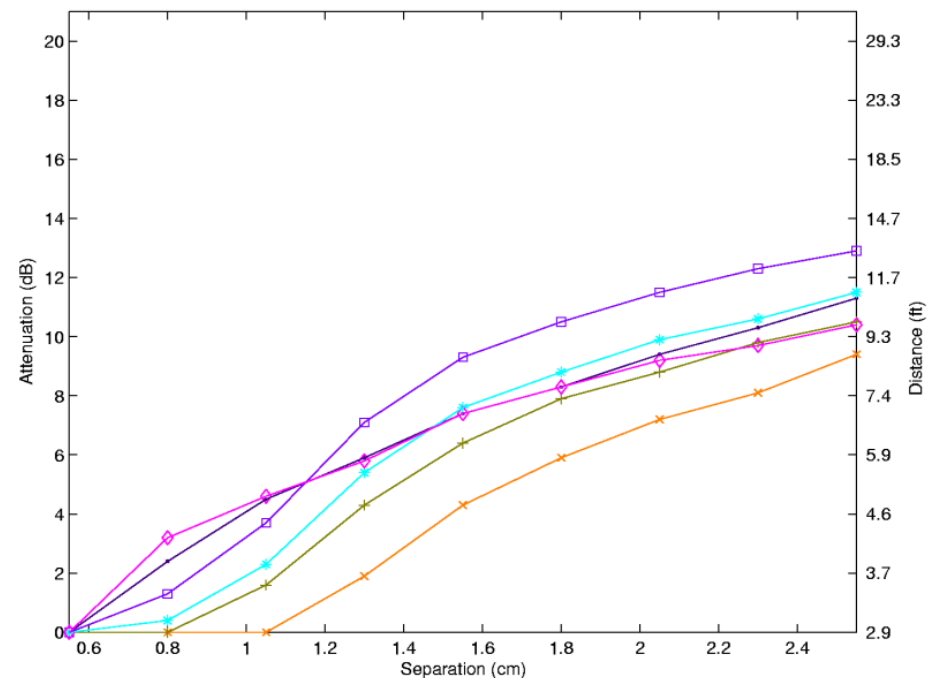
Characteristic of large, square/triangle

- Read performance nearly uniform in all orientations

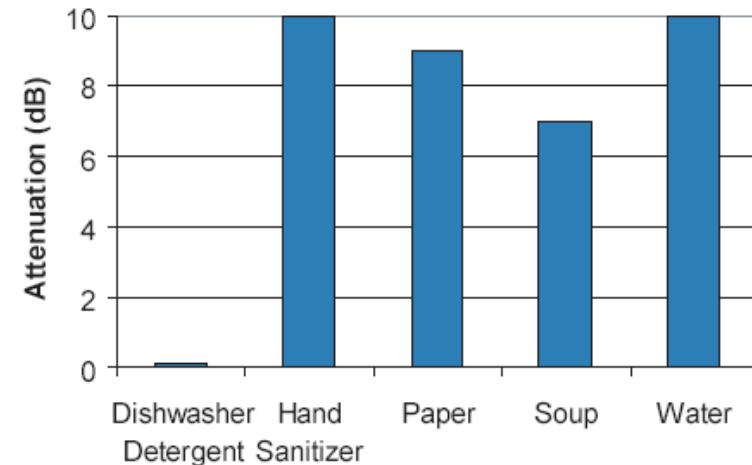
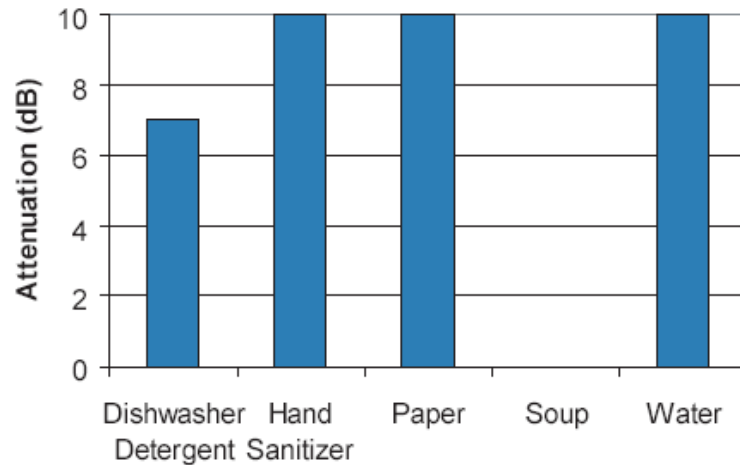
## Performance of Class 1 Tags near Water

Differences readily  
apparent

- Pink best close, but shallow slope
- Purple good close, but best further
- Best tag:
  - 150% more efficient
  - 60% further distance

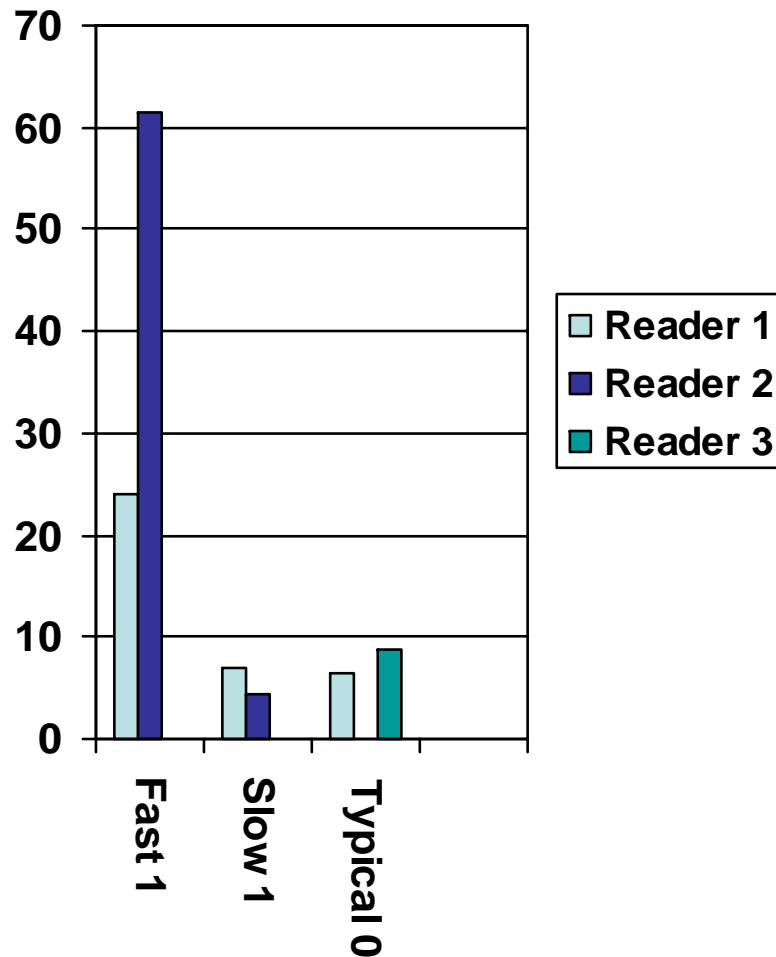


## Performance of Tagged Cases on Conveyor



- Least scientific test conducted
  - 2400 measurements taken
- Interesting experiment — objective is to get as far away from metal/water as possible
- Size of tag plays large role
  - Smaller tags get bigger air gaps

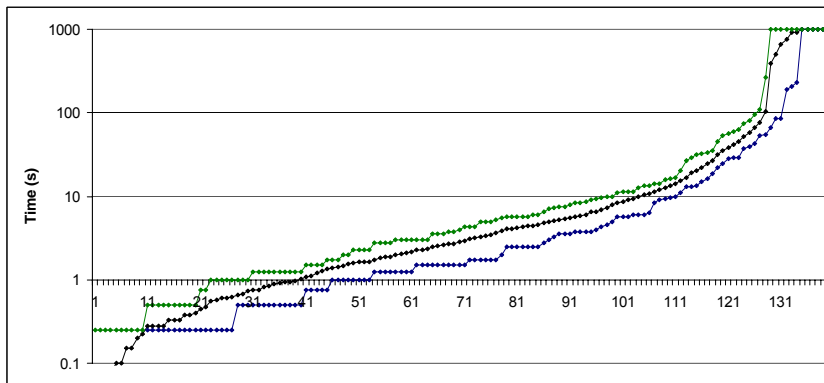
## Tag Read Rate in Isolation



- Two groups of Class 1 tags:  
Fast and Slow
  - Used recommended / default parameters for reader
  - May need to tune reader
- Class 0 tags steady

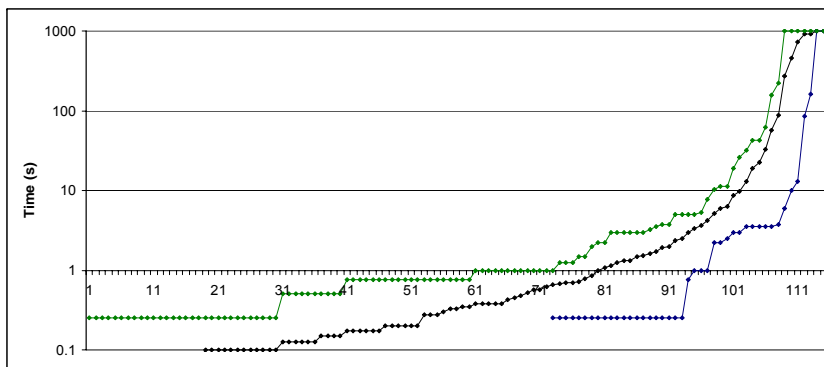
## Read Rates in Populations — Equipment





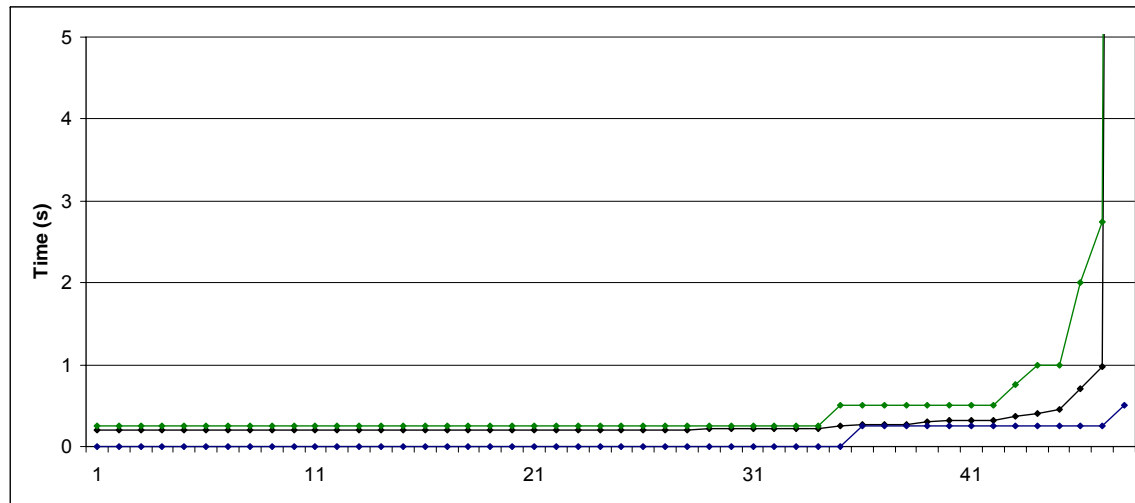
## ~140 Class 1 tags

- Perform experiment 10 times; show worst, median, best
- Note: Log Y axis
- Linear TTFR until about 85-90 tags, then exponential
- Last few tags unreadable

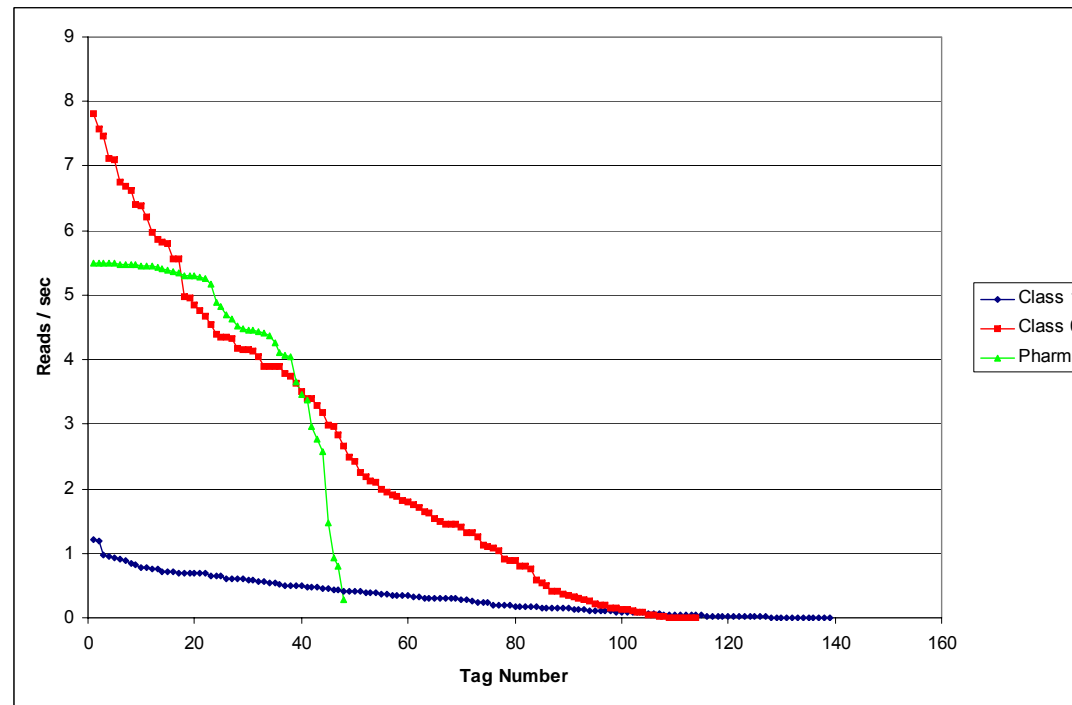


## ~115 Class 0 tags

- Exponential past ~70 tags
- Much faster than Class 1



- 48 Pharma tags, 42 on one plane
- Note: Linear Y axis
- Always reads 45 tags in 1 second, 47 in 3 seconds.
- Last tags are problematic!



## Speculate:

- Class 0 & Class 1 tags all weak-in-field
- ~2/3 Pharma strong-in-field
- Class 0 scales much better than Class 1



- RFID Alliance Lab:
  - Developing scientific benchmarks
  - Reporting findings without bias
- Our observations frequently don't match "hype"
  - Today's RFID tags have read rates varying from as low as 20 tags/second to over 1,000 tags/second (quoted without reference)
  - We've observed a range of 0 to 62
- Future efforts:
  - Work with Advisory Board
  - Durability
  - Readers
  - With consumers directly to solve your problems